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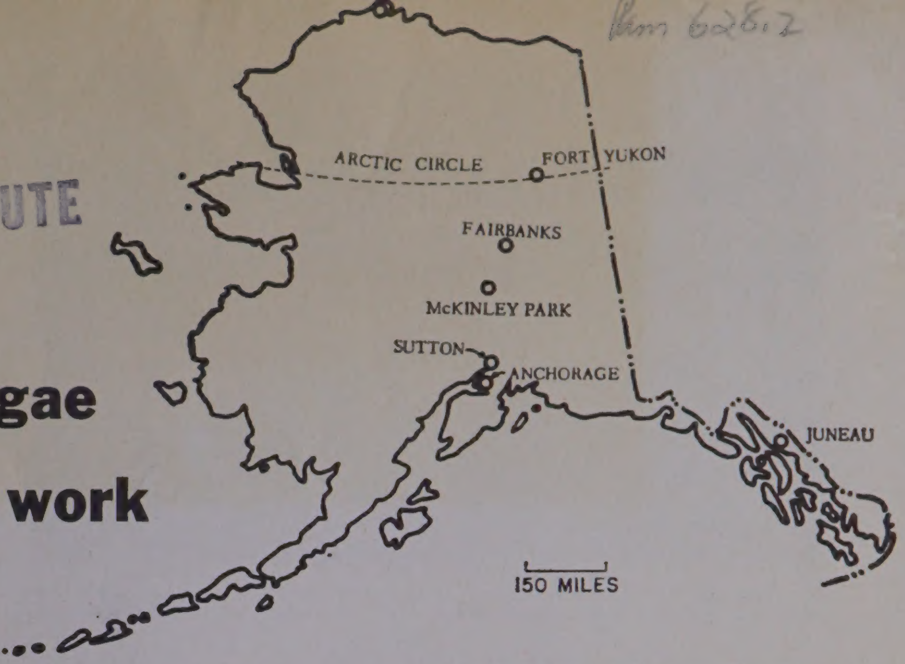
"Eskimo" algae make lagoons work at the Arctic Circle



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IN AN EFFORT to obtain an inexpensive means for treating domestic sewage in arctic and subarctic environments, the Arctic Health Research Center is investigating the use of sewage lagoons in Alaska. By observing several lagoons over the past three years, the investigators have concluded that they are practicable and operational, even under such extreme climatic conditions as might be found in Fort Yukon. The problem has practical implications for Alaska, the largest state in the nation because its 160,000 civilian residents are scattered over an area of 586,000 square miles, in temperatures ranging from 90° above zero to 60° below zero.

Twelve factors affect design

Some of the important factors to be considered in the design of sewage lagoons are: (1) The amount of light available; (2) temperature; (3) wind; (4) evaporation, precipitation, and seepage; (5) area and loading; (6) depth; (7) shape; (8) proximity to habitation; (9) soil characteristics; (10) type of inlet and outlet devices; (11) public health implications, such as mosquito propagation and proximity to underground water supplies; and (12) a properly identified enclosure.

The treatment process is still in an experimental stage with respect to Alaska, and the investigative work is far from complete. No attempt has been made to formulate design criteria for operation under arctic or subarctic environments.

During the past six years, interest in sewage lagooning has been revived on a nationwide basis, principally through the efforts of state health departments and of various research investigators. This method of sewage treatment has been proven and recommended in several northern states, including North and South Dakota and Montana, where temperature variations are almost as extreme as in Alaska. In a survey of a number of lagoons in the Dakotas, W. W. Towne and others found that temperatures as low as minus 32° F and ice as thick as 41.5 inches did not adversely affect the reduction of organic matter or the over-all operation of the lagoons. The investigation at the Arctic Health Research Center stemmed largely from this observation.

Briefly stated, a lagoon is generally a diked area, rectangular or square in shape, that retains sewage. The symbiotic activity of algae and bacteria, stimulated by sunlight, effects a reduction in sewage organic matter and leaves a relatively inoffensive liquid.

The treatment process is *not* based on allowing the liquid portion of the wastes to percolate into the ground. As such, then, sewage retention is one of the more important design considerations, and the amount of sewage retained is determined by application of the following formula: The sum of precipitation, plus sewage inflow, equals evaporation, plus percolation, plus overflow. In essence, the sum of these five items should be zero in order to maintain a depth which will provide the proper environment for the biological flora responsible for oxygen production in the lagoon. Experience in the continental United States has shown that an optimum depth of 2.5 to 3.0 feet must be maintained to permit maximum penetration of sunlight to the pond bottom, while at the same time inhibiting weed growth.

How lagoon loading is expressed

Loading is generally expressed in terms of the number of individuals contributing to the sewage flow per acre of lagoon, or the number of pounds of organic matter, measured as BOD, contributed to the lagoon per acre per day. Fitzgerald and Rohlich have indicated that loadings as high as 1,000 people per acre are considered a safe limit in Europe; whereas in North Dakota, due to lagoons freez-

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Fort Yukon sewage stabilization lagoon during summer months with sampling platform at right. Even in extreme winter temperatures of —60°F, the lagoon did not freeze completely

ing over, the recommended loading is 100 people per acre, or 20 pounds of BOD per acre per day.

Other design criteria suggested by Towne et al, and considered pertinent to Alaska, include: (1) That the pond be located one-quarter mile from the nearest residence or habitation because of odor problems that *may* occur during the spring transitional period from anaerobic to aerobic conditions; (2) that consideration should be given to the direction of prevailing winds and proximity of water supplies; (3) that investigation of soil characteristics be made in order to determine the porosity of the ground; (4) that the area around the pond be adequately fenced and appropriate signs displayed.

Three lagoons are in service in Alaska at this time. The conditions existing in these units are described below.

Sutton lagoon

The sewage lagoon at Sutton, 61 miles from Anchorage on the Glenn Highway, was designed for a population of 50 persons. This figure was based on the number of transients at a roadhouse called the Alpine Inn and the number of permanent residents at an adjacent trailer court. Originally, it was planned to include only wastes from the roadhouse and, provided the lagoon functioned satisfactorily, to add the wastes from the trailer court. As yet, the trailer court wastes have not been sewered to the lagoon.

The lagoon is located approximately 500 feet from the Inn and it is 100 feet square at the bottom of its sloped sides. An effluent ditch will carry overflow about 900 feet to the Matanuska River when the lagoon fills. Consulting engineers designed the lagoon for a summer operating depth of 3 feet, with freeboard provision for winter storage to a depth of 5 feet. Based on a 25-gpcd contribution and a total lagoon volume of 456,000 gallons, a detention period of one year has been provided. The organic loading is 129 people per acre.

For the first two years of operation, until the fall of 1959, the lagoon at Alpine Inn did not retain liquid. Several unsuccessful attempts were made to seal the bottom to prevent percolation. Water from a nearby silt-laden stream was diverted to the pond, and after this failed, clay was hauled in and spread over a portion of the bottom thought to be leaking, but both of these efforts failed until late 1959 to reduce the percolation rate. Because the unit did not retain sewage until just before freezeup in October, a previously planned schedule of monitoring the pond has been deferred until the summer of 1960. Despite an accumulation of sludge around the center inlet during the initial difficulties with the unsealed pond bottom, odors were not detectable at the roadhouse.

Fort Yukon lagoon

A lagoon serving the new elementary school at Fort Yukon was designed in 1956 by a consulting engineer with the assistance of the AHRC staff. Sewage treatment is provided for approximately 200 children and three school teacher apartments. Like the lagoon at Alpine Inn, the Fort Yukon unit was approved by the Alaska Division of Health as an experimental facility to permit observation of the effects of extreme climatic conditions, including long periods of thick ice cover.

An 1,100-foot six-inch wood-stave pipe carries the sewage from a sump in the schoolhouse to the inlet structure in the middle of the 125-foot square area. Although an overflow has been provided, no effluent has been discharged since sewage first began entering the lagoon in September 1957.

Based on a population of 200, the loading for this pond is 425 people an acre, considerably higher than the one at Sutton. Observations on a number of sump pump discharges indicate a daily discharge to the lagoon of 2,200 gpd, or 11 gpcd. Accordingly, the detention time at a 3-foot level would be approximately 200 days. From available information, the lagoon never freezes completely. Even during severe temperatures of —60°F, maximum depth of ice recorded was 18 inches.

During breakup in 1958, some odors were noticed, but they disappeared within 100 feet from the lagoon. During the spring breakup of 1959, the transition from anaerobic to aerobic conditions took place without any odors.

It should be reiterated that the lagoon is still an experimental method of sewage treatment in Alaska. Although the installation at Fort Yukon has not become a nuisance, it cannot be said that all lagoons in Alaska will function as well. There are too many unsolved variables influencing lagoon operation for an investigator to be able to predict satisfactory performance for every unit, especially in this climatic zone. For instance, the fundamental principle underlying stabilization lagoons, that of photosynthesis, depends upon the amount of sunlight available for plankton growth. Therefore, a lagoon in Fort Yukon might well be expected to perform better because of the greater amount of sunlight present in the summer months. In addition, it must be remembered that this particular lagoon is loaded only during the school term and has the remaining summer months to effect stabilization.

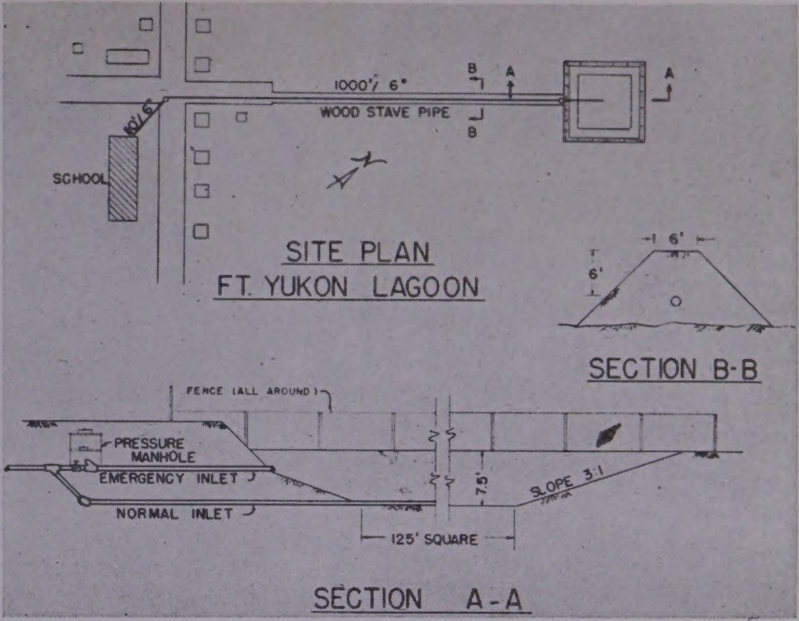
A two-week field survey of this unit was initiated May 10, 1959, at which time the impoundment was covered with ice. By May 20, the ice had disappeared, and microscopic examinations of biological samples revealed no algal organisms. On May 30, however, the algal population, representing two genera of unicellular *Chlamydomonas* and *Chlorella*, had risen to over 746,000 per ml; this level was sustained until June 13. During this period, there were no noticeable odors.

Concomitant with the large numbers of algae, chemical analysis revealed a pH above neutral and dissolved oxygen readings in excess of 30 ppm. In the light of existing information, these data indicate a functional and metabolically balanced system.

During the period June 16 to June 20, the numbers of organisms dropped from 29,000 per ml to 0 per ml, and by June 27, following the complete disappearance of *Chlamydomonas* and *Chlorella,* the genus *Closterium* made its appearance and remained, to the exclusion of all other algal groups, until August 8.

From a biological point of view, the shift from *Chlorella* and *Chlamydomonas* to that of *Closterium,* is significant, since the latter organism generally does not tolerate a septic or sewage environment. *Closteria,* which are not generally regarded as efficient stabilizing organisms, are common in acidic pools in Alaska, usually Sphagnum bogs. Although their role as an agent for stabilizing wastes is dubious, they serve at least as index organisms, showing that most of the organic compounds have been reduced to an innocuous state.

The stabilization pond at Fort Yukon is unique in that it is loaded only during the winter months, at which time an adequate ice cover prevents the spreading of obnoxious odors. Following the disappearance of the ice in the spring, it appears that complete stabilization is attained within one month. The biological mechanisms responsible for such an accelerated reduction of wastes is contingent upon the long daylight hours, which provide the necessary solar radiation for photosynthetic activity in the algae. Furthermore, the bottom of the pond is composed of essentially chemically inert sand which allows for a minimum of interference in the biological processes. In this regard, it is known that soils common to most of interior Alaska are acidic by virtue of indigenous vegetation, and therefore deleterious to plankton activity.

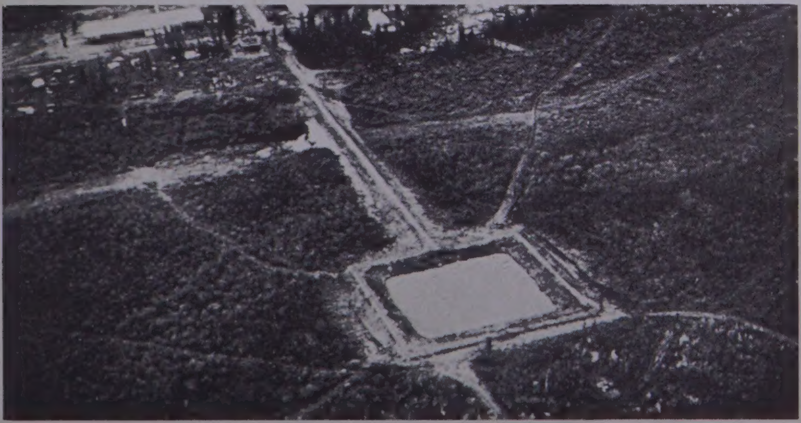


Mt. McKinley Park Lagoon

In 1957, AHRC personnel learned of a sewage lagoon that was operating at the Mt. McKinley Park Hotel. Subsequent investigation revealed a shallow, irregularly shaped area that received the overflow from a septic tank. The lagoon, approximately 100 feet by 35 feet, was at that time receiving about 10 per cent of the septic tank effluent, while the remaining liquid flowed down the hill and seeped into the nearby ground. In 1958, AHRC recommended that the entire flow be diverted to the lagoon. Thereafter, it was determined that the lagoon received a daily flow of 24,000 gallons, which resulted in a detention period of only four days.

Information concerning the plankton from the McKinley Park lagoon is somewhat fragmentary. A sample obtained on August 24, 1957 revealed the following dominant algae: *Chlamydomonas*—107,400 per ml; and *Euglena*—29,200 per ml, or 3.7 *Chalmydomonas* to 1.0 of *Euglena.* These organisms were homogeneously dispersed and the pH of the water was 7.9. These are healthy symptoms for a lagoon, considering that the skies were overcast and it has been raining a week prior to sampling. Two samples taken the following year, in June and July, 1958, indicated the same high ratio between the aforementioned genera. It was at this time that the entire septic tank effluent was diverted to the lagoon, producing a significant biological change. Sampling revealed a decided decrease in ratio between the two genera until, on August 18, 1958, the *Chlamydomonas* disappeared completely, while the *Euglena* was beginning to decrease in number.

A shift in dominance of *Euglena* over *Chlamydomonas* indicates that very likely the pond was overloaded at that time, especially since it is assumed that the euglenoids are more tolerant of higher concentrations of sewage, especially in the anaerobic stage, than is *Chlamydomonas.* Furthermore, chemical analyses indicated an organic loading of approximately 330 pounds of BOD per acre per day, or 2,000 people per acre. It would appear that at the time the pond was getting 10 per cent of the effluent, it was inadvertently being utilized to nearly full capacity. With the additional loading, the stabilization lagoon acted as a settling basin. □□



Sewage lagoon serves the Fort Yukon public school, eight miles north of the Arctic Circle. "Spokes" radiating from lagoon are footpaths and dogsled trails

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